INSTRUMENTS & TECHNIQUES

A simple device for measuring the volume of small objects

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A simple and sensitive device for measuring the volume of small biological specimens such as eyes or brains is described. This easily constructed volumeter is more accurate than a graduated cylinder and does not compromise the integrity of the tissue.

The experimenter who needs to estimate the volume of a small object such as a brain or eye faces a dilemma. On the one hand, a relatively accurate estimate of the object's volume can be made, via the principle of fluid displacement, if the object is placed into a sensitive graduated cylinder (e.g., a 10-ml capacity cylinder with 0.1-ml graduations). On the other hand, small brains and eyes are usually too large for these cylinders. Presently, there are three solutions to this dilemma. First, a larger capacity graduated cylinder can be used; however, this results in a loss of accuracy. Second, the experimenter can crush the tissue so that it fits into a sensitive graduated cylinder, but if the integrity of the tissue must be maintained, this solution is not acceptable. Third, an indirect estimate of volume may be obtained. For example, the volume of an eye may be estimated by its weight, if it has been established previously that there is a high correlation between eye volume and eye weight. The drawback of this technique is that its validity rests on the accuracy of previous measurements.

We have constructed a relatively simple device for sensitive and accurate volume estimates of small objects (see Figure 1). This instrument consists of two interconnected parts: a calibrated buret (0.1-ml graduations) and a reservoir. The opening of one end of the buret is fitted with a rubber stopper, and the opening of one end of the reservoir is fitted with a ground-glass stopper; the latter is affixed to the reservoir with rubber bands. A ring stand and a clamp are used to hold the apparatus. In addition, a small clip and hooked rod, fashioned from stainless steel wire, are used for placing objects in and retrieving objects from the reservoir.

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Figure 1. A photograph of the volumeter. The buret and reservoir are indicated by the thin and thick arrow, respectively.

We use this volumeter in the following way: First, reservoir-end up, the instrument is filled with fluid. (In our measurements, 5% buffered formalin is used.) The glass stopper is replaced and secured with rubber bands, and the apparatus is inverted 180°. After the liquid refills the reservoir, the baseline level of the fluid is recorded. To measure the volume of an object, the instrument is inverted, and the object is inserted into the reservoir with or without the holding clip. The stopper is replaced and secured, and the apparatus is again inverted. After waiting for all liquid to return to the reservoir, the level of the fluid is recorded. Naturally, the difference between the baseline and final level of the liquid is the volume of the object. The object may then be retrieved using the hooked rod.

An advantage of this device is that the volume of any size or shape object can be measured as long as it fits into the reservoir, which can be made as large as desired. Also, because the buret can be removed from the reservoir, burets with finer graduations can be used.

To test the accuracy of this device, we repeatedly ($n = 30$) measured the volume of a Teflon ball. Figure 2 displays the frequency histogram constructed from these repeated volume estimates and shows that the variability of these measurements is extremely small: range=0.14 ml, standard deviation=0.03 ml, coefficient of variation=0.89%. The data also yielded mean and median volume estimates that are practically identical, 3.659 ml and 3.660 ml, respectively. The calculated volume of this Teflon ball (using the formula for the volume of a sphere, $V = \frac{4}{3}\pi r^3$) is 3.642 ml. Because the two volume estimates differ by less than $\frac{1}{2}$ of 1%, we concluded that this device accurately measures the volume of small objects.

To test the reliability of this instrument, we twice measured the volume of the eyes of chicks that had been subjected to different experimental manipulations (Gottlieb, Wentzek, & Wallman, 1985). This measure-remeasure coefficient indicated that this instrument is highly reli-

Figure 2. A frequency histogram showing the distribution of repeated volume estimates for a Teflon ball. The arrow indicates the mean.

ble: $r(67) = 0.958$, $p < .01$. In addition, the line of best fit for these data yielded a slope approximating 1 and an intercept of almost 0 ($y = 0.98X + .01$), indicating that repeated measurements of the same object are virtually identical.

In summary, the device described in this paper can provide direct, sensitive, and accurate volume estimates of small objects such as brains and eyes without compromising the integrity of the tissue.

REFERENCES

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